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PROSPECTING FOR AND PROCESSING OF BAUXITE

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PROSPECTING FOR AND PROCESSING OF BAUXITE

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1. Bauxite, the raw material of aluminium production

Bauxite is the most important mineral raw material of aluminium, and its significance for aluminium production is fundamental. Since at present aluminium is manufactured almost exclusively from bauxite, it is clear that the importance of bauxite as a mineral raw material increases parallel to the growth of aluminium production. In 1951 aluminium production amounted to 1,99 million tons only, while in 1960 it reached 4,46 million tons. Bauxite production increased similarly during this period: from 10,5 million tons to more than 27 million tons.

The growing demand for, and interest in, aluminium may be explained by the attractive properties of aluminium. It is a light metal /specific gravity 2,7/ of considerable stability, the solidity and corrosion resistance of which can be increased by alloying. It is suitable for casting, rolling, pressing, i.e. rendering it fit for industrial employment within a wide range. It is characteristic of the growing use of aluminium in the industry, that the rate of growth of aluminium consumption has been larger than that of steel; while the annual increase of primary aluminium utilization on a world scale between 1950 - 1960 reached the 14 %, the use of crude steel grew by 6,1 % only. Although the rate of increase of aluminium utilization has been slower since /between 1956 - 1960 the use of primary aluminium showed an annual increase of 6,7 % against the 4,75 % for crude steel/, an average annual increase of 6 - 7 % in consumption can be expected further on /1/. Aluminium is to-day the most important light metal.

The large-scale increase of aluminium production has brought about the corresponding development of prospecting for and research into the raw material. Prospecting is aimed at the discovery of new bauxite deposits in order to augment existing reserves of ore, while research work tries to find technological processes, as will permit the indirect production of aluminium from a non-bauxite raw material. The vigorous geological prospecting of the past one and a half decades has resulted in discovering vast bauxite deposits, e.g. in Guinea, Cameroon, North-Australia, Jamaica, Surinam and, last but not least, in Kazakhstan /Soviet Union/. Although geological exploration in several places has had a preliminary nature allowing only a very rough estimate of the volume of the deposits and the quality of the bauxite, the world's bauxite reserves seem to be significant and sufficient to cover the raw material requirements of aluminium production for long decades.

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1. A. Väth: Stand und Entwicklungstendenzen der Aluminiumindustrie. Metall. /March, 1962/.

Beside bauxite, owing to their high aluminium content, several minerals such as nepheline, leucite, alunite, kaolinite and feldspar may be considered for the production of alumina /Al_2O_3/. Since several large aluminium-producing and consuming countries do not possess sufficient quantities of bauxite reserves of their own, research has been conducted to find rocks ocurring in large masses, and containing one or the other of these minerals to be used as aluminium ore. Methods have been completed for the processing of aluminium-rich clay, high alumina shale in connection with coal deposits, nepheline syenite, alunite and kaolin. These already include such raw materials as are employed economically on an industrial scale; in the Soviet Union nepheline-syenite is processed in a complex way with the addition of limestone, yielding alumina, calcined soda, potash and cement as the end-product. Yet the overwhelming part of alumina is still produced to-day all over the world from bauxite. Therefore the position of bauxite as the most important mineral resources of aluminium production has not changed. It can be expected that this will be so for a long time, since the production of alumina from bauxite is, for the time being, more economic than alumina production from other minerals.

Consequently the bauxite resources represent a considerable economic value and sources of power and, in case of proper utilization, may become an important factor in the economic life of the country. The distribution of the bauxite reserves in the various parts of the Earth is very unequal and the richness in raw material of the countries possessing aluminium industry is very different. A number of large aluminium-producing countries have no bauxite resources of their own, as Canada, Germany, Norway, Japan, Czechoslovakia, Switzerland, or only in insufficient quantities as the United States and Italy. Built and developed on an entirely or overwhelmingly indigenous bauxite basis are among others, the aluminium industries of the Soviet Union, France, China, Hungary and Yugoslavia. Thus several countries are in need of bauxite imports and turn their attention to countries having excess reserves of bauxite and are therefore in a position to export same. Many of the economically under-developed countries - in South America, Africa, Asia - have considerable bauxite deposits. The exploitation of the economic value of these mineral resources is of primary interest to the above-mentioned countries.

2. The occurrences and production of bauxite

Bauxite is a sedimentary rock consisting of several essential and additional mineral components. Its most important essential component is aluminium oxyde hydrate that may be tri- /hydrargillite $Al_2O_3.3H_2O$/, monohydrate /boehmite $Al_2O_3.H_2O$, diaspore $Al_2O_3.H_2O$/, or mixed tri- and monohydrate. A practically constant component is silica that may be found principally in the form of aluminium hydrosilicate /kaolinite, chlorite, etc./, rarely in the form of free quartz.

From an industrial point of view the most important criterion is the quantity and proportion of aluminium oxide and silica. For its numerical expression in most cases the values of base and the bauxite quotient /modulus/ are applied. The base expresses the amount of recoverable alumina, while the bauxite quotient expresses the relation of Al_2O_3 % to SiO_2 %.

Bauxite occurs in very different geologic conditions: in some places there are extensive deposits of several square kilometres, in others again there are lenses filling in the surface depressions of the underlying stratum, or small-sized pockets. Accordingly, the amount of the bauxite material also varies: there are contiguous masses consisting of tens of millions of tons whereas in other places we find only a few thousands or hundreds of tons of bauxite. Within one occurrence, the quality of the rock is as a rule not uniform, since the quality of the bauxite itself varies according to the kind, amount and proportion of the mineral components.

In addition to bauxite, genetically familiar rocks occur as well, such as the bauxitic clay, refractory clay and clay.

The underlying stratum, that is to say the surface on which the bauxite occurrence has developed, is in some places an eruptive rock /mostly basic and intermediary/, in other plees phyllite, shale, clay, frequently limestone and dolomite, rarely sand or other rocks. Bauxite is often sperated from the underlying rock through unconformity, indicating considerable differences in geological age. The geological age of the various deposits may be different, since under suitable terrain and climatic conditions, bauxite may have been formed in different periods of the history of the Earth. Bauxite is known in every continent, except in the Antarctic. The number of its occurrences is extremely high and therefore here we can only mention the most important ones for industry. In Europe the largest deposits may be found in the Mediterranean region and in the Carpathians basin. They have the following geological features in common: the underlying rock is limestone and dolomite, and the bauxite lies in the carstic depressions or cavities of the carbonate bedrock. /2/ As regards their geological age, they are of Triassic, Cretaceous and Eocene origin. The deposits in the counties of Var, Bouches du Rhone and Herault in the South of France, in the region of the Dinari mountains on the territory of Yugoslavia and Greece and in the Transdanubian central mountains in Hungary, are considerable even on a world-wide scale. In the Soviet Union the lower-carboniferous Tikhvin deposits on upper--Devonian clay and sand layers, in the Northern part of the Russian Table are significant. In the Eastern foreground of the North-Ural, the medium-Devonian bauxite deposits of Severouralsk, with their vast reserves, are renowned. The underlying rock is lower-Devonian limestone. In Kazakhsatn large deposits have recently been descovered in the region of the Turgai basin. Here the Cretaceous-Paleocene terrestric formation enclosing the bauxite is deposited on mainly Carboniferous and Devonian limestone and shale layers. Large bauxite deposits of the Carboniferous age have been reported from the Central Kueichou and Central-Yunnan provinces of China, and deposits of the Permian-Triassic age, from the provinces of Central-Shantung, South-Sechuan and South-Liaoning. Significant are the lateritic-type bauxite deposits on hornfels, in the Riau islands of Indonesia. Extensive deposits are known in India on the Cretaceous trap basalt of Dekkan, formed like the Tertiary products of the lateritic weathering of basalt. Of great significance are the lateritic-type bauxite deposits formed on Tertiary strata of clay and sand, discovered during the past decade on the peninsula of Cape York in Northern Australia.

There are rich deposits in Africa, too. The vast bauxite reserves of Guinea deserve to be mentioned; they were formed in the Tertiary, mainly owing to the lateritic weathering of dolerite. The lateritic bauxite deposits of the Adamua plateau of Cameroon cover an enormous area, and very considerable are the similarly lateritic-type Tertiary deposits of Ghana.

The largest deposits of the United States are in Arkansas: they were formed by lateritic weathering in the Eocene on nepheline-syenite basement rock. Much larger are the bauxite deposits of the Carribean region, particularly of Jamaica. Here bauxite is deposited on medium-Eocene-lower-Miocene limestone strata, and is therefore of the carst type. It was formed during the younger Tertiary. In Brazil the lateritic-type bauxite deposits of the Minas Gerais represent large quantities. In some places they were formed on phyllite, in others on nepheline-syenite, in the Tertiary and Quaternary. The deposits of Brit.Guyana and Surinam are similarly of the lateritic type and young in age. Some of them are very significant. Recently a particularly large deposit has been discovered in the Bakhuis mountain of Surinam.

The bauxite reserves of the world are considerable: according to present estimates their total volume may approach 5,000 million tons.

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2. E.Vadász: The geology of Bauxite, Budapest /1961/. In Hungarian.

The exploitation has been going on in many places for various lengths of time. In 1961, the most important bauxite producing countries were the following /3/:

Jamaica	6,2oo million t.
Soviet Union	3,9oo[x]
Surinam	3,353
France	2,182
British Guyana	1,788
Hungary	1,358
Guinea	1,355[x]
United States	1,232
Yugoslavia	1,220
Greece	1,o5o

/x = estimated value./

Only the United States and the Soviet Union process the total of their bauxite production, while the others export a major or minor part of same, and some /Surinam and Greece/, their total production. The yield in Jamaica, Guinea, the Soviet Union, France, Hungary, Yugoslavia and Greece, has shown an increasing tendency during the past few years. In 1961 the total bauxite production of the world amounted to some 27,5 million tons. Its value increased since 1950, according to the Deutsches Institut für Wirtschaftsforschung /4/, in the following way:

1950	Dollars	65 million
1953	"	115 "
1956	"	139 "
1957	"	151 "
1958	"	166 "
1959	"	180 "

In most places of occurrence, bauxite is produced by opencast mining. There are, however, underground mines aswell: in the United States, France, Hungary, Yugoslavia and of particularly large capacities in the Soviet Union. Hungary obtains 67 % of her bauxite yield, from underground mines.

Considering a further increase in demand and production and owing to the gradual exhaustion of the existing mines, new occurrences will have to be initiated for cultivation. It is therefore necesaary to make provisions for suitable bauxite reserves.

3. Bauxite exploration

The prospecting for raw materials of mineral origin usually starts within the frame of general, geological mapping. Concerning the dimensions of the mineral occurrence, the quantity and quality of its reserves such prospecting generally yields approximate data which may be used for initial economic estimates only. The full extent and value of the occurrence of a mineral raw material can, in the first place, be learned by an appropriate geological exploration aimed explicitly at the desired mineral. It is chiefly in this way that the instruments, methods, material-testing processes, best suited to the geological conditions and to the mineral-petrological characteristics of the mineral material, as well as the experts may suitably be chosen to ensure fast and efficient work.

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3. Mining Journal. Annual Review /1962/
4. Revue de l'Aluminium. No. 294 /Oct. 1961/.

The prospecting for, the preliminary and detailed investigation of, bauxite occurrences should be undertaken within a specialized exploratory program performed partly by big private enterprises, partly by State institutions or enterprises. The explorations, for instance, in the Northern--Ural bauxite regions of the Soviet Union and also in Hungary, are conducted by State enterprises formed for, and specialised in, bauxite research.

In the interest of speeding up the acquisition of information and of increasing the efficiency of operations, it is advisable to conduct the research work step by step: in the first stage, comprising prospecting, the places of occurrence should be ascertained; in the second stage - preliminary exploration - the occurrences already established are outlined and approximate information is gained on the reserves. In the third stage, which may be called exploration in detail, the occurrence should be thoroughly investigated and the quantity and quality of the reserves should be estimated accurately. Naturally, in the various fields of exploration, work may reach simultaneously different stages. In the course of work the principle of complex execution should be enforced even in the case of specialized prospecting for a raw material of mineral origin, that is to say, the other mineral materials appearing in the course of the prospecting operations should also be considered and assessed. It is advisable to classify the various fields of exploration according to their dimensions and economic significance, to carry out the work of prospecting in the various fields, in such a succession as will permit the acquisition of the optimum geological information and to explore the places of occurrence in accordance with the economic value that may be expected of them. The work of prospecting should have a sound economic foundation and the amount spent on exploration should be in proportion to the results obtained.

The generally employed means of bauxite exploration are the geological mapping, sinking of trenches and pits, manual and mechanical drilling. The scale of the geological mapping, further the density applied in the location of trenches, pits and drillings should always conform to the stage of exploration in order to obtain a proportional amount of geological data. In the course of the preliminary and detailed exploration, the pits or drillings are located according to a regular pattern. In the case of exploration by drilling, it is advisable to employ core drilling for the cross-cutting of the totality of the bauxite, in order to obtain a proper quantity and quality of rock material available for the chemical and technological tests.

In several instances geophysics may be employed with advantage for bauxite prospecting, principally through electric, magnetic and seismic measurements. These geophysical measurements are aimed, in most cases, not at the material establishment of the bauxite, but at the detection of such structures or layer succession, as are generally connected with bauxite occurrences. The material confirmation of the bauxite itself is the task of the geological prospecting following geophysics. Refraction seismic measurements have successfully been applied in Arkansas /USA/, and vertical electric sounding and magnetic measurements in Kazakhstan /USSR/.

The quality of bauxite is ascertained by chemical, mineral-petrological and technological tests. These determine its chemical and mineral composition and the method and extent of its industrial utilization. The chemical analysis is completed either in the wet way or by spectroscope. The mineral components are established partly in an optical way and partly by the differential thermoanalysis, thermogravimetry, and X-ray methods usually employed in clay--mineral investigations. The technological investigations consist mainly of digestion, in order to determine the amount of the available alumina.

In some places bauxite prospecting also demands hydrogeological investigations, since some bauxite deposits are connected with subsurface water

and considerable water invasion may appear in the course of mining.This is frequent particularly in carst-bauxite deposits situateddeep under the surface and under the regional carst-water level of the area. Such occurrences prevail in the North-Ural and in certain bauxite areas of Hungary. For this very reason in these places, bauxite prospecting is accompanied by energetic hydrogeological investigations.

Following the determination of the extension and thickness of the occurrence, as well as the volume weight and quality of the bauxite, the qualitative classification of the reserves and the calculation of the quantity can be effected. The classification of the bauxite by quality is a function of industrial requirements and varies greatly in the individual countries. In various countries the quality is determined by industrial norms.

The accuracy of the reserve estimation depends on the amount and reliability of the data available. In view of the fact that a useful economic and industrial evaluation can only be effected on the basis of precise and reliable reserve-data, the particulars regarding the reserves are, as a rule, rated in order to indicate the degree of accuracy and reliability. In the United States the terms "measured", "indicated" and "inferred", are applied for this purpose. The Soviet Union and several other countries, including Hungary, express the extent to which investigation of the reserves has been completed and the degree of reliability of the data by the so-called category indication. These categories are as follows: A, B, C_1 and C_2 of which A indicates the maximum extent and C_2 the minimum extent of investigations completed. In addition, category D is used to indicate inferred reserves. In general a mine can only be settled for reserves qualified in their majority by A+B+C_1.

The data of geological exploration of a suitable extent serve as a basis for the assessment of the economic value of individual occurrences or of whole bauxite areas.

4. Processing

The most important phase of bauxite processing is the production of alumina, from this the production of aluminium, and to a small extent, the production of cement, abrasives, paint and filter materials. Here we wish to deal only with the most important phases: the production of alumina and of aluminium.

a./ The production of alumina. Alumina is usually obtained by the Bayer, and the soda-lime sintering processes, further by the parallel and series--combined process developed from the coupling of the two. At present some 75 % of the world's alumina production is obtained by the Bayer process. For the processing of high-quality bauxite with low silica content, mostly the Bayer process is used, while for poor-quality bauxite with considerable silica content, the sintering or the combined processes are employed. For the production of 1 ton of alumina, 2-3 tons of dry bauxite are necessary, depending on the quality of the bauxite. With the Bayer process, the aluminium-oxyde-hydrate content of the bauxite is digested by a caustic soda solution, then the solution obtained in this way and rich in sodium-aluminate is diluted and allowed to settle, so that the red mud should separate. The retained pure solution is cooled and the aluminium-hydrate separated in precipitation tanks by way of hydrolisis, then it is heated to alumina. The digestion of the pure trihydrate bauxites is possible at atmospheric pressure, therefore their digestion requires less thermal energy and generally lower costs than in the case of the monohydrates. With the soda-lime sintering process the ground bauxite, the soda and the limestone are blended and heated to calcine at a high temperature /1,100 - 1,300 C°/, in consequence of which the aluminium-oxyde content of the bauxite will be transformed into natrium-

aluminate to be extracted from the calcine. Thereafter the hydrate may be segregated from the solution containing natrium-aluminate, through treatment by carbon dioxide or by stirring. The investment and working costs of the sintering process are higher than those of the Bayer process, the contamination of the alumina by silica is higher, therefore it is applied for the processing into alumina of such bauxites only, as have a significant silica content /7 - 12 %/ and consequently, in case of employing the Bayer process, high and expensive caustic soda losses would occur. The volume of the alumina produced by the pure sintering process amounts only to some 5 % of the world's total production.

Another method for producing alumina is the combination of the Bayer and the sintering process. With the parallel-combined process good-quality bauxite will be digested in the Bayer branch and poor-quality bauxite in the sintering branch, and the caustic soda loss of the Bayer branch will be supplemented by the natrium-aluminate that will be formed out of the soda employed in the sintering branch. For the economy of the process, the capacity of the two service branches should be so dimensioned as to permit the soda application of the sintering branch just to supplement the caustic soda loss of the Bayer branch.Consequently with this process of alumina production, some 80 - 85 % of the production will be on the Bayer service branch. The process is more widespread than pure sintering and is employed principally in the Soviet Union and in Italy. It accounts for about 13 - 15 % of the world's alumina production.

With the series-combined process, generally the poor-quality, bauxite with high silica content isworked up: at first the material is treated according to the Bayer method, then the red mud still containing a relatively large quantity of aluminium oxide is digested by the soda-lime sintering process. In thisway the loss of caustic soda is smaller than in case of the Bayer process, the thermal-energy requirement is smaller than with the pure sintering process, yet the alumina yield will be still favourable. The process is employed, according to our knowledge, in the United States, and the alumina obtained in this way, accounts for 5 - 5,5 % of the world production.

In addition to the methods of alumina production mentioned in the foregoing, several other patented methods are known, yet only a few of them have found employment in the industry.

The by-products of alumina production may partly be utilized; for instance, the iron content may be recovered from the red mud formed in the course of the Bayer process, and vanadium and gallium are selected in Hungary from the salts. Approximately 90 - 91 % of the world's alumina production is used for the manufacture of metal aluminium, hence, on the whole, an equilibrium has been established on a world scale between the alumina--producing capacities and those of the aluminium plants, although in several places the location of the alumina-producing plants does not coincide with that of the aluminium plants. Namely transport expenses will work out in the most favourable way, if the alumina plant is settled near the bauxite base and the aluminium plant near the power works, if this is possible at all. For this reason the tendency is to place the alumina plants as close, as possible to the bauxite mine and the aluminium plants near the power source. Such requirements have recently been met when building the alumina-producing plants in Jamaica and Guinea. According to G.A. Baudart /5/, relying on the situation in June 1960, the alumina capacity of the West is estimated 830 thousand tons higher than the amount of alumina required to meet the smelting capacity, and the actual equilibrium may be ascribed to alumina consumers

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5. G.A. Baudart: Étude systématique de approvisionnements en alumine dans le monde en 1960. Revue de l'Aluminium No.284./Febr.1961/.

other than the aluminium plants. The supplies of alumina available in the consuming countries varies greatly; in some places there is a shortage, in others again an excess, which accounts for the lively international trade in alumina. In view of the above-mentioned requirements to be met in settling alumina and aluminium plants, a significant alumina trade is to be expected also in the future. The highest alumina capacities exist at present in the United States, the Soviet Union and Canada.

b./ The production and utilization of the aluminium. Aluminium is produced through the electrolysis of alumina /Al_2O_3/ between carbon electrodes in a cryolite melt, under the use of about 1,9 specific alumina and a large amount of electric power. Hence the provision of the required electric power is a primary condition of aluminium metallurgy. The specific consumption of direct current in the average furnaces is of the order of 16 - 17,000 kWh/1 t of aluminium, and even in the up-to-date furnaces operating with high current intensities /80,000 - 100,000 amperes/, it is 14,500 - 15,000 kWh /6/. This accounts for the fact that economical primary aluminium production is only possible where a large quantity of cheap electric power is available.

Formerly aluminium metallurgy used exclusively cheap energy obtained from hydroelectric power stations, while in the course of the last three decades, power produced by the thermal power stations has become competitive. Unlike hydroelectric power stations, thermal power works possess the advantage, that their current supplies are uniform throughout the whole year, while the current supplied by hydroelectric power stations changes periodically, depending on the water supplies.

The thermal power stations working for aluminium metallurgy utilize black coal, brown coal or natural gas as fuel. Recently the smelter capacity produced by thermal power has increased particularly in the United States: by the end of 1961, the capacity of aluminium plants operating on hydroelectric power has amounted to 1,154,000 tons, while that of the aluminium plants operating on thermal power amounted to 1,296,000 tons /7/. The overwhelming majority of aluminium plants of the world, however, still employ electric power obtained from water power stations and plants are still settled economically on a hydroelectric power base as shown by the recent establishment of the aluminium plant in Cameroon and by the plan for building a vast smelter in Ghana /with an end-capacity of 210,000 tons/ within the so-called Volta project.

According to preliminary figures, the world's production of primary aluminium in 1961 amounted to 4,446,000 l.tons./3/. This is the participation of the most important countries /in thousands of l. tons/:

United States	1,700	Italy	82
Soviet Union	740	China	80
Canada	580	Austria	67
France	275	Hungary	50
Norway	170	Poland	47
German Federal Rep.	170	Cameroon	45
Japan	147	Switzerland	41

The chief aluminium-consuming countries are the United States, the Soviet Union, Britain, the German Federal Republic, France, Japan, Canada.

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6. H. Schmitt: Neue Gesichtspunkte beim Bau von Aluminium-Elektrolysenöfen. Zeitschrift für Erzbergbau und Metallhüttenwesen. No. 9. /Sept. 1961/.
7. E. Rauch: Hydroelektrische und thermische Energie in der Aluminiumherstellung. Metall /March, 1962/.

Aluminium being an important industrial raw material very much in demand a significant part of primary aluminium is handled by international trade.

In 1960, for instance, nearly 25 % of the world's primary aluminium production was exported. According to G.A. Baudart, the principal exporting countries in 1960 were the following /8/:

Country	Export in % compared to production	Participation of the country in %, of world exports.
1. Canada	72,5	44,3
2. United States	14,1	22,9
3. Norway	83,5	12,2
4. France /including Cameroon/	29,6	7,2
5. Soviet Union	8,5	6,0
6. Austria	32,0	1,9
7. Others	2,4	5,5

The number of countries importing primary aluminium is very high: the most important ones are Britain, the German Federal Republic, the United States, Belgium and Italy.

The industrial utilization of aluminium is manifold, and the fields of its employment widen all the time: transport and the production of vehicles, building industry, electrical engineering, machinery and apparatus manufacture, food and packaging industry, metallurgy of non-ferrous metals and powder metallurgy, chemical industry, the manufacture of utensils and household articles and mass products.

According to statistics compiled by A. Väth, aluminium consumption in the West in 1960 was as follows: /1/

Transport	18,5 %
Building industry	17,0 %
Electrical engineering	12,2 %
Packaging	7,9 %
Production of machinery and apparatus	7,8 %
Metallurgy, powder-metallurgy and desoxidation	4,4 %
Others	32,2 %
	100,0 %

Of course, in the various countries the extent of utilization is very different, in accordance with the demands of consumption and the industrial advancement of the particular country.

In certain economically and industrially developed countries the per capita consumption has already reached 5 - 10 kg/capita, however, on a world scale the average is 1,5 only. On the basis of growing aluminium consumption,

8. G.A. Baudart: Les grands courants de l'aluminium dans le monde. Revue de l'Aluminium No. 294 /Jan. 1962/.

it may be inferred that by 1970 the consumption will have reached the value of 2,7 kg/capita /9/.

5. The possibilities of utilizing bauxite resources and the respective assistance.

The profitable exploitation of the bauxite resources depends on the economic strength, industrial development, power sources of the respective country, further on the requirements of home consumption and its capacity of absorbing the goods, and finally on the chances of export. Bauxite can be sold as an ore abroad or can be processed inland and the product so obtained, sold on the home or foreign markets.

An economically underdeveloped country can easiest develop bauxite production, since this claims little investment, few means of production, and a relatively small number of technically trained personnel, particularly in the case of openeast mining. From the point of view of transportation, marketing and employment, it is of advantage to couple the production of bauxite with the manufacture of alumina, yet here substantially larger investments and a higher degree of technical preparedness will be required. In possession of rich power resources, principally hydroelectric power, water power station and the building of an aluminium plant close to it, may already be considered. This requires considerable investments, particularly the building a hydro-electric power station. In under-developed countries the production of half-finished or finished aluminium ware is generally established in accordance with the requirements of home consumption.

The efforts aimed at the utilization of bauxite may be different in the various regions, depending on natural conditions and the degree of exploitation. In some of the under-developed countries, bauxite production may already have reached considerable proportions, yet they may have no or only an insignificant alumina production. This is the situation prevailing in certain countries of the Carribean area, where efforts are made to develop a corresponding alumina production capacity, based on their own bauxite resources. In other areas again as for instance in some West-African countries, even the production of bauxite is low as compared to the existing possibilities. Here, considering the natural endowments, not only vast bauxite production and manufacture of alumina could be developed, but the production of aluminium could be based on hydro-electric power. This was started in Guinea, Cameroon. Nor have the rich bauxite resources of several other areas been sufficiently exploited.

The production of bauxite and the establishment of an industry for processing demands proper engineering skill and equipment as well as capital, which in the case of an under-developed country may not be available. The technical and economic aid to be offered by the advanced countries is therefore a necessity. Their assistance may consist of sending or training experts, of making engineering or economic plans, of placing at their disposal means of production or transportation, of the offering of credits or of other financial aid. In this way the bauxite resources not yet utilized, or not satisfactorily utilized in several countries may be exploited . Thereby new centres of the aluminium industry will be created in areas with vast bauxite resources, and included in exploitation to satisfy the growing consumption of aluminium. In this way assistance will become mutually profitable.

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9. Revue de l'Aluminium, No. 283. /Jan. 1961/.

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